CONSTANT VELOCITY JOINT OF TRIPOD TYPE

FIELD OF THE INVENTION

The present invention relates to a constant velocity joint of tripod type, which is disposed between rotating shafts connected at a joint angle with each other in a drive axle of, for example, an automobile, for transmitting a rotational torque.

BACKGROUND OF THE INVENTION

Tripod type constant velocity joints are one of a number of types of constant velocity joints used in drive axles of, for example, automobiles. For example, Japanese Laid Open Patent Application Nos. S63(1988)-186036 and S62(1987)-233522 disclose a tripod type constant velocity joint 1, as shown in Figures 15 and 16. This constant velocity joint 1 is provided with a hollow cylindrical housing 3 which is secured to an end of a first rotating shaft 2 serving as a drive shaft or the like on the differential gear side, and a tripod 5 which is secured to an end of a second rotating shaft 4 serving as driven shaft or the like on the wheel side. Grooves 6 are formed at three locations on the internal face of the housing 3 at an even spacing in the circumferential direction and extend outwardly in the radial direction of the housing 3 from said internal face.

On the other hand, the tripod 5 secured at one end of the second rotating shaft 4 comprises a unified form of a boss 7 for supporting the tripod 5 at one end of the second rotating shaft 4, and trunnions 8 formed on three locations at equal spacing around the boss 7 in the circumferential direction. Around the

respective trunnions 8 each of which is cylindrically formed, rollers 9 are rotatably supported through a needle bearing 10, while allowing the rollers to be displaced in the axial direction by certain distances. A joint is provided by engaging the respective rollers 9 with the recess 6 on an inner face of the housing 3. The respective pairs of side faces 11, on which each of the above recesses 6 is provided, are formed to circular recesses. Accordingly, each of the rollers 9 is rotatably and pivotably supported between the respective pairs of the side faces 11.

When the constant velocity joint 1 as described above is used, for example, the first rotational shaft 2 is rotated. The rotational force of the first rotational shaft 2 is, from the housing 3, through the roller 9, the needle bearing 10 and the trunnion 8, transmitted to the boss 7 of the tripod 5, thereby rotating the second rotational shaft 4 the end of which is fixed to the boss 7. Further, if a central axis of the first rotational shaft 2 is not aligned with that of the second rotational shaft 4 (namely, a joint angle is not zero in the constant velocity joint 1), each of the trunnion 8 displaces relative to the side face of each of the recesses 6 to move around the tripod 5, as shown in Figures 15 and 16. At this time, the rollers 9 supported at the ends of the trunnions 8 move along the axial directions of the trunnions 8, respectively, while rolling on the side faces of the recesses 6, respectively. Such movements ensure that a constant velocity between the first and second rotational shafts 2 and 4 is achieved, as is well known.

If the first and second rotational shafts 2 and 4 are rotated with the joint angle present, in the case of the constant velocity joint 1 which is constructed

and operated as described above, each of the rollers 9 moves with complexity. For example, each of the rollers 9 moves in the axial direction of the housing 3 along each of the side faces 11, while the orientations of the rollers 9 are being changed and further the rollers 9 displace in the axial direction of the trunnion 8. Such complex movements of the rollers 9 cannot cause a relative movement between a peripheral outside face of each of the rollers 9 and each of the side faces 11 to be smoothly effected. Thus, a relatively large friction occurs between the faces. As a result, in the constant velocity joint 1 of Figures 15 and 16, three-directional axial forces occurs per one rotation. It is known that an adverse oscillation referred to as "shudder" may occur in some cases, if a large torque is transmitted with a relatively large joint angle present.

To prevent any oscillation from occurring due to the above cause, for example, Japanese Laid-Open Patent Application No. H3(1991)-172619 discloses a structure shown in Figure 17 and Japanese Publication Patent Application No. H4(1992)-503554 discloses structures shown in Figures 18 and 19.

In the case of a structure shown in Figure 17, since movement of an outer roller 16 and an inner roller 12 in an axial direction of a trunnion 8 is limited, when a constant velocity joint of the structure rotates at a joint angle, a large amount of frictional resistance is generated due to any axial displacement between the inner cylindrical face of the inner roller 12 and the spherical trunnion 8, applying a pressing force onto the inner roller 12 and the outer roller 16, and then producing

a frictional force preventing the inner roller 12 and the outer roller 16 to be rotated with each other.

Moreover, since an area of contact between the inner cylindrical face of the inner roller 12 and the spherical trunnion 8 is small, when torque is transmitted through the contact area during rotation at a joint angle, it is susceptible to wear and damage.

In the case of the joint shown in Figure 18, the number of components is increased since an element is provided for determining the location of an inner roller relative to a partially spherical trunnion, and also the machining process is relatively complicated.

In the case of the joint shown in Figure 19, since the inner roller are deformed in assembling, a wall thickness of an inner roller is in part reduced causing it to be relatively weak.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a tripod type constant velocity joint which is both highly strong and durable, and which can maintain a low axial force and low shudder when transmitting torque at an angle.

In order to attain the above object, a constant velocity joint of tripod type according to the first aspect of the invention comprises:

a cylindrical hollow housing defining an opening at one end, and being secured at its opposite end to a first rotating shaft such that a central axis of the housing is aligned with that of the first rotating shaft, an inner face of the

housing being provided with three guide grooves extending in a axial direction of the housing and being spaced apart equally in a circumferential direction, each groove having a pair of side faces opposed to each other, extending in the axial direction, and a bottom portion connecting between the side faces; and

a tripod provided at an angle normal to a second rotating shaft and secured to one end of the second rotating shaft, the tripod having three trunnions positioned in the grooves, the trunnions being spaced apart equally in a circumferential direction and securing equally to the second rotating shaft at an angle normal, with respective inner rollers being mounted to outside end portions of respective trunnions, and with respective outer rollers being mounted on the outer faces of inner rollers through needle bearing, the outer faces of the outer rollers being shaped so as to allow movement only in an axial direction of the grooves, each of the trunnions having a generally spherical outer face, and each of the inner rollers having a generally spherical outer face, respective generally spherical outer faces of the inner rollers having approximately same dimensions as respective generally spherical outer faces of the trunnions such that respective inner rollers may rotate and pivot freely on respective outer faces of respective outer face of respective trunnions.

The constant velocity joint of tripod type is characterized in that, on each outer face of each trunnion, there is provided a partially cylindrical area inclined relative to a trunnion centerline (Q), wherein the trunnion centerline (Q) means a line passing through a center (O) of the generally spherical outer face of the

trunnion, perpendicular to a trunnion axis (M) of the trunnion, and being on a face including the trunnion axis (M) and a portion in contact with the inner roller, with a joint angle being zero; and

wherein the trunnion axis (M) means an axis passing through the center (O) of the generally spherical outer face of the trunnion, and perpendicular to the second rotating shaft.

In order to attain the above object, further, a constant velocity joint of tripod type according to the second aspect of the invention is characterized in that:

a diameter (d) of each partially cylindrical area provided on each outer face of each trunnion is related to an inner diameter (D) of each inner joint end surface of each inner roller in accordance with the following formula:

$(d) < (D)$

and $5° \leq$ angle (θ),

wherein the angle (θ) is an angle of a line connecting between the center (O) of the trunnion and a farthest point (P), relative to the trunnion centerline (Q), an intersection line (13a) being an edge line of the partially cylindrical area at an inner side of a joint, the farthest point (P) being on a location where the intersection line (13a) is farthest from a center of a joint, on the outer face of the trunnion.

The present invention can provide a tripod type constant velocity joint which is both highly strong and durable, and which can maintain a low axial force and low shudder when transmitting torque at a joint angle.

These and other objects and advantages of the present invention will be more apparent from the following detailed description and drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows cross-sectional views of a primary portion of a tripod type constant velocity joint according to the first embodiment of the present invention, where Figure 1(a) is a longitudinal cross-sectional view, and Figure 1(b) is a cross-sectional view;

Figure 2 is a cross-sectional view of the first embodiment of the present invention;

Figure 3 is an explanatory view showing the first embodiment of the present invention, where Figure 3(a) is an explanatory view showing the assembly of a roller, and Figure 3(b) is an explanatory view showing an area that receives a load during movement;

Figure 4 is a cross-sectional view of a primary portion of the second embodiment of the present invention;

Figure 5 is a cross-sectional view of a primary portion of the third embodiment of the present invention;

Figure 6 is a cross-sectional view of a primary portion of the fourth embodiment of the present invention;

Figure 7 is a cross-sectional view showing a state of the fourth embodiment of the present invention with any joint angle present;

Figure 8 is an explanatory view showing a state of the fourth embodiment of the present invention in which a load is applied at one side of the trunnion;

Figure 9 is a view corresponding to Figure 8 with a joint angle present;

Figure 10 is a cross-sectional view of a primary portion of the fifth embodiment of the present invention;

Figure 11 is a cross-sectional view of a primary portion of the sixth embodiment of the present invention;

Figure 12 is a cross-sectional view of a primary portion of the seventh embodiment of the present invention;

Figure 13 is a cross-sectional view of a primary portion of the eighth embodiment of the present invention;

Figure 14 is an explanatory view showing a state of edge contact of the eighth embodiment of the present invention;

Figure 15 is a schematic perspective view showing a conventional tripod type constant velocity joint;

Figure 16 is a schematic partial cross-sectional view taken along the line A-A of Figure 13;

Figure 17 is an explanatory partial enlarged view of a conventional tripod constant velocity joint;

Figure 18 is an explanatory partial enlarged view of an another conventional tripod constant velocity joint; and

Figure 19 is an explanatory partial enlarged view of a still another conventional tripod constant velocity joint.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described with reference to the drawings.

Figure 1 shows cross-sectional views of a tripod type constant velocity joint according to the first embodiment of the present invention, incorporated in a drive system of, for example, an automobile; wherein, Figure 1(a) is a longitudinal cross-sectional view, and Figure 1(b) is a cross-sectional view with a joint angle being zero.

A constant velocity joint 1 shown in Figure 1 comprises a hollow cylindrical housing with one end defining an opening, and the other end secured to an end of a first rotating shaft 2 serving as a drive shaft or the like, with a tripod being secured at one end of a second rotating shaft 4 serving as a driven shaft or the like on a wheel side. On the inner surface of the housing 3 there are provided three grooves 6 which are equally spaced in a circumferential direction, and positioned at equal distances from the axis of the first rotating shaft 2. The grooves 6 are recessed from the inner surface outwardly in radial direction of the housing 3.

A tripod 5 is secured at one end of the second rotating shaft 4 and comprises a boss 7 for supporting the tripod 5 at one end of the second rotating shaft 4, with three trunnions 8 being formed at equal spacings around the boss 7 in the circumferential direction, which will be described later. An inner roller 12 and an outer roller 16 of a roller assembly are mounted on each of the trunnions 8 with needle roller bearings 10 so as to rotate freely. Then, a joint is constituted by fitting these outer rollers 16 into the grooves 6 of said housing 3. In addition, a pair of parallel side faces 11a and 11b defining the groove 6 have spherical concave surfaces, respectively. The outer roller 16 is supported between the pair of side faces 11a and 11b so as to roll and pivot freely.

When the constant velocity joint 1 as described above is used, for example, the first rotational shaft 2 is rotated. The rotational force of the first rotational shaft 2 is transmitted from the housing 3, through the roller 9, the needle bearing 10 and the trunnion 8, to the boss 7 of the tripod 5, thereby rotating the second rotational shaft 4 the end of which is fixed to the boss 7. Further, if a central axis of the first rotational shaft 2 is not aligned with that of the second rotational shaft 4 (namely, a joint angle is not zero in the constant velocity joint 1), each of the trunnion 8 displaces relative to a side face of each of the recesses 6 so as to pivot around the tripod 5. At this time, the outer rollers 16 supported at the ends of the trunnions 8 roll and move on the side faces 11a,11b of the guide grooves 6, respectively, thereby absorbing any axial relative displacement occurring between

the outer rollers 16 and the inner rollers 12. Such movements ensure that a constant velocity between the first and second rotational shafts 2 and 4 is achieved.

Next, the first embodiment of the present invention will be described in detail with reference to Figures 2 and 3.

Figure 2 is a cross-sectional view showing a tripod type constant velocity joint 1 of the first embodiment of the present invention with a joint angle being zero. Figure 3(a) is an explanatory view showing an assembly of the inner rollers 12 on the trunnions 8; and Figure 3(b) is an explanatory view showing an area of the trunnions 8 which receives a load.

As described earlier, the tripod type constant velocity joint 1 according to the first embodiment comprises a hollow housing 3 secured at an end of a first rotating shaft 2 (shown in Figure 1(a)) serving as a drive shaft or the like and a tripod 5 secured at one end of the second rotating shaft 4 serving as a driven shaft or the like on the wheel side. Grooves 6, which are provided as recesses extending in the axial direction (a direction extending between the front side and the rear side in a paper of Figure 2) are formed on three locations at equal spacing on the inner face of the housing 3 in the circumferential direction, and are recessed radially from the inner faces toward the outside of the housing 3.

Moreover, each of the guide grooves 6 of the housing 3 comprises a pair of opposed side faces 11a,11b and a bottom portion 11c continuously connected to the both side faces. The side faces 11a,11b correspond to a convex spherical outer face of the outside roller 16, and hence is formed as a circular

recessed surface of approximately the same dimension as the outer face of the outside roller 16. The side faces 11a,11b extend in the longitudinal direction of the housing 3 or the axial direction of the first rotational shaft.

Each of the bottom portions 11c of the guide grooves 6 is provided with the tracking guides 18a and 18b for guiding each of the outer rollers 16 in contact with the outside end surface of the outer roller 16. In this way, the side faces 11a,11b of the guide grooves 6 provide a tracking surface on which the outside roller 16 can slide and roll.

The trunnion 8 has a generally spherical convex outer surface, the center of which lies along the trunnion axis (M) (described later); in addition, a partial cylindrical face 13 is formed on the outer surface of the trunnion 8 so as to be inclined relative to the trunnion centerline (Q) (described later). On the outer surfaces of the trunnions 8, respective inner rollers are mounted to enable the trunnions to pivot and rotate freely. The inner surface of the inner roller 12 has a generally spherical inner face which has similar dimensions to the outer surface of the trunnion 8, and is mounted directly on the outer surface of the trunnion 8. In addition, the inner roller 12 has a cylindrical outer surface; and the outer roller 16 has a cylindrical inner surface, With the outer roller 16 being engaging with the inner roller 12 through the needle bearings 10. Further, the outer face of the outer roller 16 is in part spherical.

Next, the way in which the inner roller to the trunnion 8 will be described.

Figure 3(a) is an explanatory view showing the steps of fitting the inner roller 12 having an inner spherical surface to the trunnion 8 having an outer spherical surface.

When (D) means an inner diameter of the end face of the inner roller 12 at the joint inner side and (d) means a diameter of a partially cylindrical area 13 which is inclined relative to the trunnion centerline (Q) (described later), the relation of (d)<(D) exists. Consequently, as shown in Figure 3(a), after making the end face of the inner roller 12 at the joint inner side parallel to the partially cylindrical area 13 and bringing the inner roller 12 into contact with the trunnion 8, it becomes possible to install the inner roller 12 on the trunnion 8 by rotating the inner roller 12 with the inner face of the inner roller 12 being in contact with the outer face of the trunnion 8, as indicated by the arrows A1 and A2 in Figure 3(a). After installing the inner roller 12 on the trunnion 8, an allowable amount of pivot (of pivot angle) of the inner roller 12 on the outer spherical surface (the direction indicated by arrow A2 in Figure 3(a)) of the trunnion 8 is limited enough small to prevent detachment during using the joint.

Next, with reference to Figure 3(b), the load applied to the trunnion 8 during operation will be explained. As shown in Figure 3(b), a point (O) is defined as a center of the trunnion 8 which is perpendicular to the second rotating shaft 4 (see Figure 1) and has a spherical convex face, and a trunnion axis (M) is defined as an axis which passes through the center (O) of the trunnion 8.

In addition, with a joint angle being zero, a trunnion centerline (Q) is defined as a line which is on a plane including a contact portion where the trunnion 8 is in contact with the inner roller 12, and the trunnion axis (M), and which passes through the center (O) of the spherical end surface of the trunnion 8 and is perpendicular to the trunnion axis (M).

Moreover, a farthest point (P) is defined as a point which is on a location farthest from a joint center among points of the intersection line (13a) on the outer surface of the trunnion 8.

When (θ) is defined as an angle of a line connecting between the farthest point (P) and the center (O) of the trunnion 8, relative to the trunnion centerline (Q), the angle (θ) is set to be $5° < (\theta)$. Thus, a relatively large spherical outer surface area of the trunnion is provided for receiving a load applying onto the outer face of the trunnion 8. Accordingly, an area for receiving the load is increased, thereby enabling contact stress to be dispersed.

According to the first embodiment of the invention, when the joint 1 is rotated with the usual joint angle present in attaching to an automobile, a force occurs due to up and down movements of the trunnion 8 relative to the outer roller 16 in the axial direction of the trunnion 8 (access of the roller). This force can be absorbed because the outer face of the inner roller 12 slides and rotates on the inner face of the needle bearing 10 located between the outer roller 16 and the inner roller 12. Thus, a sliding resistance of the outer roller 16 can be significantly reduced or minimized, as compared to a pure sliding resistance of the prior art structure.

The above operation allows the outer roller 16 and the inner roller 12 to be stabily rolled with low friction. Hence, a constant velocity joint of a tripod type of the embodiment can be highly strong and durable with a low axial force.

In addition, in the first embodiment of the present invention, as shown in Figure 2, the outer roller 16 is provided with needle bearing retaining rings 15 and needle bearing stop rings 24, at each of its upper and lower ends, respectively.

Next, the second embodiment of the present invention will be described with reference to Figure 4.

Figure 4 shows a structure employed to prevent needle roller bearings from becoming dismounted in a tripod type constant velocity joint according to the present invention.

The basic structure of the tripod type constant velocity joint of Figure 4 has the same structure as that defined in the first embodiment, as shown in Figure 2. However, in the structure shown in Figure 4, needle stoppers 16a and 16b are formed integral with the outer roller 16 around both circumferential ends of an inner cylindrical area of the outer roller 16, so that the number of components can be reduced.

Alternatively, it is also possible to constitute a structure wherein only a single needle stopper, either 16a or 16b, is formed to be integral with a circumferential end of an inner cylindrical area of an outer roller 16 and the other needle stopper is a separate member.

Next, the third embodiment of the present invention will be described with reference to Figure 5.

Figure 5 shows a structure which prevents needle bearings from becoming dismounted in a tripod type constant velocity joint according to the present invention.

The basic structure of the tripod type constant velocity joint of Figure 5 has the same structure as that defined in the first embodiment, as shown in Figure 2. However, in the structure shown in Figure 5, needle stoppers 12a and 12b are formed integral with the inner roller 12 around both circumferential ends of an outer cylindrical area of the inner roller 12, so that the number of components can be reduced.

Alternatively, it is also possible to constitute a structure wherein only a single needle stopper, either 12a or 12b, is formed to be integral with a circumferential end of an outer cylindrical area of an inner roller 12 and the other needle stopper is a separate member.

Next, the fourth embodiment preferable to the present invention will be described.

Figures 6 through 9 are explanatory views of a tripod type constant velocity joint to be incorporated in the drive system of, for example, an automobile, according to the fourth embodiment of the present invention. Figure 6 is a cross-sectional view showing a tripod type constant velocity joint according to the fourth embodiment of the present invention. Figure 7 is a cross sectional view showing the

trunnion 8 with any joint angle present. Figure 8 is an explanatory view of the trunnion 8 in which a load is applied onto only one side of the trunnion 8. Figure 9 is an explanatory view of the trunnion 8 on which a load is applied, with any joint angle present.

The main difference in the fourth embodiment from the first embodiment is that there is an offset between a trunnion centerline (Q) and a groove centerline (N). This will be described later. In the fourth embodiment, the same components as used in the first embodiment of the present invention will be indicated by the same symbols. The details regarding the different components will be described in detail hereinafter.

In Figure 6, a groove centerline (N) is shown as a straight line connecting the arc centers of recessed circular side faces 11a and 11b of the guide groove.

When the joint is rotated with any joint angle present, the trunnion centerline (Q) of the trunnion 8 shifts toward the inside of the joint relative to the groove centerline (N) as shown in Figure 7. If there is a large offset toward the inside of the joint from the groove centerline (N) to the trunnion centerline (Q) with a joint angle being zero, the offset is more increased with a joint angle present. If the offset become more large as in the latter case, the outer roller 16 receives a load on the groove centerline (N), while the inner roller 18 receives a load on the centerline (Q), as shown in Figure 8. As a result of an offset between load points onto the loads are applied, a counter clockwise moment is generated around an axis

connecting the both loaded points, in Figure 8. This moment tends to rotate the outer roller 16 counterclockwise toward the inner direction of the joint (the direction shown by an arrow in Figure 8) at the opposite side of the loaded points. Thus, the moment causes the outer roller 16 to be highly pressed onto inner radial side of the housing 3 of the side face 11a of the guide groove at the opposite side of the loaded points, bringing about any undesirable resistance to a rotation of the outer roller 16 which would be desirable to be avoided.

In the fourth embodiment of the present invention, as shown in the Figure 6, the offset (δ) between the trunnion centerline (Q) and the groove centerline (N) with a joint angle being zero is set to be $-0.02Ro < \delta \leq 0.093Ro$, wherein Ro is a radius of outer face of outer roller (16). Therefore, the offset can be kept small with any joint angle present. Consequently, it is possible to eliminate a generation of excessive moment on the outer roller 16, thereby avoiding excessive contact pressure between the groove 11a of the housing 3 and the outer roller at the opposite side of the loaded side; whereby it is possible to obtain a low axial force and minimizes any rolling resistance acting against the outer roller 16.

Next, the fifth embodiment of the present invention will be described with reference to Figure 10.

The main difference in the fifth embodiment from the first embodiment is that the inner diameter (φdo) of the rim 16b formed at the end of the inside of the joint on the inner cylindrical surface of the outer roller 16 is made to be smaller than the outer diameter (φDi) of the inner roller 12. In Figure 10, like

components described in the first embodiment of the present invention, and shown in Figure 2, are designated by the same symbols. Additionally, since the basic structure of the fifth embodiment of the present invention is the same as that of the first embodiment, primarily, the details regarding the different components will be described hereinafter.

Figure 10 is a cross-sectional view showing the fifth embodiment of the present invention. In the fifth embodiment, the relation (φdo) < (φDi) is provided, wherein φdo is an inner diameter of the rim 16b formed on the inner cylindrical surface of the outer roller 16 at the inside of the joint and φDi is an outer diameter of the inner roller 12. Therefore, it is difficult for the outer roller 16 to be detached from the inner roller 12. Further it is difficult for the needle bearing 10 to be detached from the inner rollers and the outer rollers, since the outer roller 16 engages with a boss of the tripod when it is moved to inner radial side. Accordingly, it can be very easy to handle the assembled tripod (in which the tripod, the inner rollers 12, the needle roller bearings 10, and the outer rollers 16 are assembled together).

Next, the sixth embodiment of the present invention will be described with reference to Figure 11.

The main difference in the sixth embodiment from the first embodiment is that the outer diameter (φDii) of the rim 12a formed at the end of the outside of the joint on the outer cylindrical surface of the inner roller 12 is made to be smaller than the inner diameter (φdoo) of the outer roller 16. In Figure 11,

like components described in the first embodiment of the present invention, and shown in Figure 2, are designated by the same symbols. Additionally, since the basic structure of the sixth embodiment of the present invention is the same as that of the first embodiment, primarily, the details regarding the different components will be described hereinafter.

Figure 11 is a cross-sectional view showing the sixth embodiment of the present invention. In the sixth embodiment, the relation (φ doo) < (φ Dii) is provided, wherein φDii is an outer diameter of the rim 12a formed at the end of the outside of the joint on the outer cylindrical surface of the inner roller 12 and φdoo is an inner diameter of the outer roller 16. Therefore, it is difficult for the outer roller 16 to be detached from the inner roller 12. Accordingly, it can be very easy to handle the assembled tripod (in which the tripod, the inner rollers 12, the needle roller bearings 10, and the outer rollers 16 are assembled together).

Next, the seventh embodiment of the present invention will be described with reference to Figure 12.

The main difference in the seventh embodiment from the first embodiment is that the longitudinal cross radius (r) of the inner roller 12 is made formed to be larger than the longitudinal cross radius (R) of the trunnion 8. In Figure 12, like components described in the first embodiment of the present invention, and shown in Figure 2, are designated by the same symbols. Additionally, since the basic structure of the seventh embodiment of the present

invention is the same as that of the first embodiment, primarily, the details regarding the different components will be described hereinafter.

Figure 12 is a cross-sectional view of the inner roller 12 and the trunnion, according to the seventh embodiment. In the seventh embodiment, when (r) is a radius of a longitudinal cross-sectional shape of an inner face of the inner roller 12 and (R) is a radius of a longitudinal cross-sectional shape of an outer face of the trunnion 8, the following relations exist;

$(r) \geq$ (diameter of trunnion (8) /2)

and $(R) \leq$ (diameter of trunnion (8) /2)

and $(R) < (r) \leq (3.8\ R)$

By setting in this way, sufficient grease-entry spaces are provided at both inner and outer sides to enable better greasing of the loaded contact area between the inner roller 12 and the trunnion. As a result, frictional resistance between the inner roller 12 and the trunnion 8 is minimized, providing remarkably improved smoothness of operation and in durability as compared with the prior art.

On the other hand, if the above radii (r) and (R) are substantially identical to each other (closely contact) as in the prior art, any axial movements of the trunnion 8 due to the rotation with any joint angle present may be absorbed only by the sliding between the inner roller 12 and the trunnion 8 in close contact therewith, thereby causing the sliding resistance to be much increased.

On the contrary, the seventh embodiment of the invention makes the radius (R) of the outer face of the trunnion 8 smaller than the radius (r) of the inner

face of the inner roller 12. Thus, the trunnion 8 moves rolling on the inner face of the inner roller 12. Accordingly, a friction between the inner face of the inner roller 12 and the outer face of the trunnion 8 can be reduced, thereby attaining a significant reduction of the axial movements of the trunnion 8.

Next, the eighth embodiment of the present invention will be described with reference to Figures 13 and 14. Figure 13 is a cross-sectional view showing the eighth embodiment, and Figure 14 is an schematical view in which the outer roller 15 and the tracking guide 18b (or 18a) are in contact with each other at their edges.

The main difference in the eighth embodiment from the first embodiment is that the outer roller 16 has a R-shaped chamfer which is in contact with the tracking guide 18b (or 18a) and is then guided by the same, and this R-shaped chamfer is continuous with the outer surface. In Figure 13, like components described in the first embodiment of the present invention, and shown in Figure 2, are designated by the same symbols. Additionally, since the basic structure of the seventh embodiment of the present invention is the same as that of the first embodiment, primarily, the details regarding the different components will be described hereinafter.

In a conventional tripod type constant velocity joint, when it is rotated with any joint angle present, an outer roller 16 rolls along the grooves 11a and 11b parallel to the first rotating shaft 2, transmitting this rotation. At this time, as shown in Figure 14, the outer roller 16 is guided by the tracking guide 18b (or

18a) and rolls with an angle of inclination (α) relative to the tracking guide 18b (or 18a), due to the axial and pivotal movements of the trunnion 8 and the outer roller 16. Additionally, the outer surface edge of the outer roller 16 makes edge contact with the tracking guide 18b (or 18a), which causes an increase in frictional resistance against movement of the outer roller.

In the eighth embodiment of the present invention, the outer surface edge of the outer roller 16 making edge contact with the tracking guide 18b (or 18a) as described above has the R-shaped chamfer which is continuous with the outer surface of the outer roller 16. Accordingly, the R-shaped chamfer of the outer roller 16 can eliminate edge contact with the tracking guide 18b (or 18a), even in a case where the outer roller 16 moves with an angle of inclination (α) relative to the tracking guide 18b (or 18a). Thus, frictional resistance against movement of the outer roller can be significantly reduced.

As described above, according to the present invention, a tripod type constant velocity joint of high-strength and high-durability can be provided with maintained low axial force and reduced vehicle shudder even when operating at an angle.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. The invention is defined by the claims.